To the Foreman ON THE JOB

Some useful
INFORMATION
for the better
execution of
REINFORCED CONCRETE

THE TRUSSED CONCRETE STEEL CO. LTD.
Reinforced Concrete Engineers
22 Cranley Gardens, South Kensington, S.W.7.

THE KAHN SYSTEM.

The Kahn System originally meant a system or method of reinforcing concrete. With the changing views on the principles of reinforcing, and the standardisation of its application, the meaning of the Kahn System has changed also. The Kahn System now stands for a complete organisation and for services which embody the experience of reinforced concrete design and construction since 1907, the year in which the Trussed Concrete Steel Company was established.

REINFORCED CONCRETE CONSTRUCTION

Handbook for the guidance of the Clerk of Works and the Foreman.

Particulars which should be in the possession of the Clerk of Works and the Foreman.

Drawings.

All drawings must be so carefully studied that the shape and the position of each reinforcing bar can be visualised. If any item of the drawings seems inconsistent or wrong, do not proceed with the work until the doubt is cleared up.

The consecutive numbering of the drawings should be checked, and if a revised drawing is received, all copies of the original drawings should be destroyed or sent off the job in order to avoid mistakes.

Particular attention should be paid to any notes on the drawings, as these may amplify the specification.

Specifications.

The specification must be followed strictly, and those sections which refer to particular parts of the work should be written out in an abbreviated form on the copy of all drawings used for reference.

Where circumstances indicate the desirability of modifying the specification the case should be referred to the architect for his decision before any departure is made.

Bills of Quantities.

The bills of quantities, if kept on the job, should be referred to only in so far as they may supplement the specification. Any apparent discrepancies should be referred to the architect and any supplementary information copied on to the specification and abbreviated on the drawings.

MATERIALS.

Generally.

The chief difficulty of anyone inspecting materials is to decide when he is justified in rejecting them and the essentials to be insisted on for work of an important or special nature. The following notes are given to assist in arriving at a decision.

Portland Cement.

Natural or slag cements should not be used. Only medium setting artificial cement, complying with the British Standard Specification and manufactured by a reputable firm is permissible.

The containers must be undamaged when the cement is received on the site, and the seal fixed by the makers to each bag should be unbroken.

Any cement containing lumps should be viewed with suspicion and carefully tested before use. In any case such lumps must be removed.

Cement should be stored in dry sheds off the ground, in such a manner that the consignments can be used up in the order in which they are received.

Where small quantities only are required, cement should be obtained from merchants who store it in a proper manner.

Modern cement does not need cooling. On the contrary it should be kept as much as possible away from the air in order to prevent it absorbing moisture, which makes it lumpy, or carbon dioxide, which retards the setting. This precaution is particularly important when handling rapid-hardening cements which, if exposed to the air, tend to lose their rapid-hardening qualities.

Most manufacturers are now willing to market their cement in paper bags instead of sacks. The paper bag is often preferable, as it is more airtight.

With the introduction of rapid-hardening cements, it is important to realise the difference beween hardening and setting. Setting takes place in the first few hours after the cement is mixed with water. The hardening process may go on for several years. Rapid-hardening cement may be slow-setting or slow-hardening cement may be rapid-setting.

If the inspector is dissatisfied with the cement he should call upon the contractor to supply a properly certified test, by a recognised testing firm, on a sample selected by the inspector himself. The test must comply with the British Standard Specification in every respect.

Tests.

The only tests of cement (apart from its general inspection) which can be made on the site and which give reliable information as to soundness, are the Le Chatelier test and the pat test.

The apparatus necessary for carrying out the Le Chatelier test consists of a small split cylinder of spring brass, to the ends of which is attached a long pointer. Full instructions for carrying out this test are supplied by the makers of the apparatus as laid down by the British Engineering Standards Association's Specifications.

The pat test requires no special apparatus and is conducted as follows :—

Two pats of cement, gauged in the usual way, each 3in. in diameter and about ¼in. in thickness, are cast on a piece of glass. One pat is placed in water after 24 hours and the other is left in the air, free from draughts or undue heat. The cement will have an undue expansion if either of these pats shows cracks when thoroughly set. Cracks appearing at the edges of the pat indicate expansion due to an excess of lime in the cement; cracks in the centre of the pat indicate contraction due to a shortage of lime in relation to the slag and alumina content. Observations of these pats should be made for a period of seven days.

Aluminous Cement.

All the above notes also apply to aluminous cements, but as the cost of aluminous cement is considerably higher than that of Portland cement, the care in handling should be correspondingly increased.

On no account should aluminous cement be allowed to mix with Portland cement or lime. All shovels, barrows, sheds, mixing boards, etc., used for the handling or storing of aluminous cements must be thoroughly cleaned before use. These precautions are necessary because aluminous cement in which there is a trace of lime or Portland cement will have a flash set and thereby be rendered useless for ordinary work.

Sand.

Assuming that the cement is of good average quality, which modern methods of manufacture have almost assured, then it is the quality of the sand which has the greatest effect upon the strength and properties of the concrete. All sand should pass a ¼in. screen and as far as possible be uniformly graded from the ¼in. down to the finest dust.

A sharp or gritty sand is of no particular advantage. A sand containing rounded particles is equally good, as these particles slide more easily into a compact formation and present a more uniform area to the compressive stresses.

The sand should consist of hard non-porous particles and be free from impurities such as coal, chalk, lime, clay, etc. The presence of clay in sand is distinctly objectionable and the clay should never exceed 5 per cent. of the total volume. Clay will reduce the strength of the concrete, increase its porosity and very greatly increase the shrinking during the ageing period. The smaller the sectional area of the member in relation to its length, the smaller is the percentage of clay that can safely be allowed in the concrete.

The presence of any appreciable quantity of organic impurities in the sand is highly dangerous. It will certainly retard the setting of the concrete and may finally result in its disintegration.

The hand-washing of sand on the site should not be attempted except in extreme or very special circumstances. It is a costly process and is usually unsatisfactory. On a large job it may sometimes pay to install a proper plant for the washing of a local sand in preference to bringing a clean sand from a considerable distance.

The most suitable sand for reinforced concrete work is one which is obtained through the crushing of the stone which is selected for the large aggregate. It is immaterial whether this crushing is natural or artificial. Ground bricks or tiles form a good substitute for sand, especially where the large aggregate is broken brick. Powdered brick acts as a pozzuolana which, by acting on the free lime liberated during the setting of the cement, forms a very hard substance which adds both to the strength and fireproof qualities of the concrete. The addition of a percentage of powdered brick or other pozzuolana to a natural sand is also advantageous.

Grading of Sand.

The principle underlying the grading of sand is that if the sand is sifted through a screen then there should be more than sufficient of the sizes passing through the screen to fill the voids in that which is retained on the screen. Ideal grading cannot, of course, be hoped for in a natural sand, but as a general rule not more than 13 per cent. of the total volume should pass through a 60 sieve and not less than 33 per cent. should pass through a 30 sieve.

Tests.

The field tests which can be carried out on sand are as follows :—

Mechanical Analysis.

A mechanical analysis suitable for field work can be carried out by obtaining three sieves, i.e., No. 10, No. 30 and No. 60. The sand to be tested should be thoroughly dried and a suitable quantity measured out. An empty match-box will be found a suitable measure for this purpose. Six measures of the sand should then be sifted on the 30 sieve, one portion being retained and the other portion passing through. The portion that is retained should then be sifted on the No. 10 sieve. What is retained on this sieve should be placed on the table in a pile marked " A." That which passed through the No. 10 sieve should be piled and marked " B." Now take the other portion of the original quantity and pass it through the No. 60 sieve. The pile which is retained on this sieve should be marked " C " and the pile which passes through this sieve should be marked " D." The sand is of poor quality if any of the piles A, B, C or D fall outside the following limits :—

Pile " D " should not be less than ½ measure and not more than 1 measure.

Pile " C " should not be less than 1½ measures and not more than 3 measures.

Pile " B " should be not less than 2 measures and not more than 3 measures.

Pile " A " should be not more than 2½ measures.

Pile " D " which contains the flour should be carefully inspected. If the particles in this pile are all very fine, do not feel gritty, and are of uniform size, the quantity should be nearer the lower limit, i.e., ½ measure. A sand which falls within the limits above specified can safely be accepted. The fact that any of the piles are outside the limit does not necessarily mean that the sand is unsuitable for reinforced concrete work, but it should not be used without a complete analysis. A full report on any sand can always be obtained by sending a sample of about ¼ cubic foot to the Trussed Concrete Steel Company.

A fairer test is obtained if the sand is first mixed with the ballast in the proportion of two parts of ballast to one part of sand and the whole passed through a ⅜in. sieve. All that portion which passes through this sieve should then be re-tested as above described. By this process the fine particles in the ballast are incorporated in the sand and a truer analysis is obtained. A field analysis should always be carried out in this way before a final decision is made.

Silt Test.

A fair sample of the sand should be thoroughly mixed and stirred in about 2 volumes of water, and allowed to settle in a glass jar of uniform sectional area. The hard particles will immediately fall to the bottom, leaving the clay in suspension. During the course of 24 hours the clay will be deposited on the top of the sand and can be measured in relation to the total volume. A clean sand will not show more than 3 per cent. of silt. If the silt exceeds 8 per cent. the sand should not be used except for mass concrete work.

Test for Organic Impurities.

A sample of the sand should be thoroughly mixed with an equal volume of a 3 per cent. solution of caustic soda in a clean glass vessel. The organic impurities will be oxidised by this solution, turning the liquid a brownish colour. If, after the expiration of 24 hours the liquid is of a darker colour than pale ale, an excessive amount of organic matter is present, and the sand should not be used for reinforced concrete work. Several of these tests should always be made and should give at least three satisfactory results out of five tests.

If a special concrete is being aimed at either in regard to strength, imperviousness to water, or fireproof qualities, a much higher standard of sand must be required. A specification to suit any special purpose can always be obtained by applying to the Trussed Concrete Steel Company.

Aggregate.

For ordinary reinforced concrete work the whole of the aggregate should pass a ¾in. mesh. Aggregate up to an 1½in. mesh may be allowed for very large members where the distance between the reinforcing bars exceeds 1½ times the largest stone. If the aggregate is graded below the ¼in. mesh then that portion should be considered as sand.

The stones comprising the aggregate should, as far as possible, be round or cubic in shape. Long flat stones do not pack well and are inclined to cause voids in the concrete. Each stone must be hard and capable of withstanding pressure.

A reasonable degree of porosity in the aggregate is not detrimental to the strength of the concrete, as by absorbing the cement better adhesion between the stones is obtained.

A porous aggregate is not suitable for concrete exposed to the weather.

An aggregate which, when crushed, leaves a very fine flour or powder adhering to the stones should as far as possible be avoided. The presence of this flour, which it is almost impossible to remove, prevents the cement paste from coming into contact with the stones, resulting in lack of adhesion.

For general purposes, coal residues, such as coke breeze and clinkers, should not be used for reinforced concrete work, owing to the difficulty in ensuring their being free from sulphur or other impurities. Slag, also, should not be used, unless its suitability has been proved by proper scientific investigation.

The purpose for which the concrete is to be used will naturally govern the decision as to the suitability of any particular aggregate. For *waterproof* concrete the aggregate must be non-porous. To withstand abrasion it must be hard and dense, and should not splinter under shock. For fireproof qualities it must be stable under heat.

Certain hard sandstones are suitable for reinforced concrete, but generally they form a concrete which is brittle, has a high contraction, and therefore is very liable to crack. Sandstones as a rule do not give a concrete of high compressive strength.

Broken brick, provided it is well burnt, forms a good aggregate, but it must be free from old lime mortar, paper, wood, rags, or other products of the demolition of old buildings.

Water.

Only fresh clean water free from chemical impurities should be used. If the water is obtained from the ordinary town supply it may be considered suitable. If the water is obtained from a well, pond or stream it should be "suspect" until its suitability has been definitely ascertained. A field test for the purity of water should not be relied upon. A sample should be taken in a thoroughly clean bottle and sent to a laboratory or testing firm for chemical analysis, and a report asked for on its suitability for use in concrete. The presence of impurities in water may seriously affect the setting properties of the cement.

It must be realised that the total volume of water in the concrete is made up of the quantity added at the time of mixing, and the quantity originally present in the sand and aggregate. The amount present in the materials can be gauged by weighing a definite quantity of the material and re-weighing after it has been thoroughly dried, the difference in weight being the quantity of water originally contained therein. This test should be repeated periodically, as the wetness of the materials will vary with the weather conditions and the time of the year.

Concrete Proportions.

When the samples of sand and aggregate have been selected, the proportion of sand to the aggregate is governed by the amount of sand necessary to fill the voids in the aggregate. In order to test the aggregate for voids a quantity should be thoroughly soaked in water to saturation and all surplus water carefully drained off. It should then be filled into a measured watertight container. Measured quantities of water should then be added until the aggregate is just covered. The volume of water thus added gives the proportion of the voids in the original quantity of the aggregate. The amount of sand used should exceed this proportional volume by about 25 per cent. so that with uneven mixing of the concrete sufficient sand is present in all parts. As the percentage of voids in most aggregates of fairly uniform size is about 40, two parts of sand are usually sufficient for four parts of aggregate.

The minimum amount of cement for a dense concrete is that volume which is necessary to fill the voids in the sand. These voids vary in accordance with the grading of the sand, but do not usually exceed 40 per cent., which gives about one part of cement to two parts of sand. We thus get the usual proportioning of concrete for reinforced concrete work as one volume of cement, two volumes of sand, and four volumes of aggregate, usually written 1 :2 :4. If a stronger concrete is required it is not advisable to alter the percentage of sand to aggregate, but only to increase the volume of the cement.

If the sand and aggregate is received ready mixed on the site and the specification for the concrete is 1 :2 :4, it is quite wrong to take one part of cement to six parts of the mixed ballast. If the two parts of sand and four parts of aggregate in the specification are mixed together it will be found that the resulting volume will be just over five parts and not six. This is due to the fact that in mixing some of the sand goes to fill the voids in the aggregate and does not increase the volume.

The architect or the engineer will usually fix the proportioning of the concrete, but latitude is given to the man on the job to vary the proportions of the sand to the aggregate after these have been selected in accordance with the principles mentioned above, providing the quantity of cement per cubic yard of concrete is maintained as specified.

It has only recently been realised that the water content of the concrete has a very material effect upon the properties of the concrete both as regards strength, porosity and contraction. Further, it has been found that the quantity of water necessary for given properties is in direct ratio to the volume of cement used. The theoretically ideal quantity of water results in a mixture the consistency of which usually causes it to be impossible to handle in practice. Excess of water is therefore inevitable, the duty of the foreman being to ensure that this excess is kept to the lowest possible limits considering the conditions under which the concrete has to be placed.

It is quite wrong to rely on tamping to get the concrete round the reinforcing steel. The men are working " blind " and cannot see the result of their work. The concrete must be of such plasticity that it will flow into position with a reasonable amount of vibration or agitation. The wetness of the concrete is only one factor towards plasticity, as it depends upon the quantity of cement and the shape, size and grading of the particles of the sand and the aggregate. The minimum degree of plasticity will depend upon the size and the nature of the member being poured, and drier concrete can be used for a flat slab than for small beams with reinforcement. It is naturally difficult to define plasticity, and the only satisfactory method is by actual test. Various concretes should be made up with measured quantities of water until the desired condition is obtained. A slump test should then be made from this concrete and thereafter a slump taken as the standard. Instructions for carrying out a slump test are usually supplied by the makers of the apparatus, but the following notes will be of assistance.

Slump Test.

The test is made with a hollow truncated cone of mild steel provided with two handles. The conical mould should be thoroughly cleansed and greased and then filled with concrete in layers of 4in., the sample of concrete being taken from the actual work. Each layer should be tamped exactly thirty times with the iron rod supplied with the apparatus, care being taken that the withdrawal of the rod does not leave a void behind it. The cone should be overfilled at first and then struck off level, the edges being slightly pressed down so that the concrete does not overlap the rim of the cone. Before attempting to lift the cone it should be slightly rotated so as to break down all adhesion. The lifting of the cone should be slow for the first inch or so and then there should be a steady withdrawal. Considerable practice is necessary with this operation to obtain a fair comparative result. The slightest tilting or pushing of the cone during its withdrawal may increase the slump by two inches or more. To measure the slump, place the iron cone alongside the concrete pat, and by means of a straight edge resting on the top of the cone measure down with a foot rule to the highest point of the concrete. This test must be carried out on a firm base large enough to take the slumped concrete and absolutely horizontal. During the test work in the vicinity should be stopped as the slightest vibration will considerably affect the result. The slump should be taken as the best of five tests.

Mixing.

Hand Mixing should only be resorted to if the conditions render the use of a mixer impracticable or uneconomical.

Hand mixing should be carried out on a properly constructed close-jointed platform of sufficient size to take four times the batch that is being mixed. The sand and aggregate should be measured out and once turned over before the cement is added. After adding the cement the mixture should be turned twice dry. The water should be added by sprinkling through the rose of a water-can during the next mixing and the mixing continued until the whole batch is evenly wetted. Twice mixed wet is usually sufficient. On no account should the water be applied through a hose.

Machine Mixing. Until a suitable type of continuous mixer has been devised, a batch mixer should be insisted upon. The mixer should be of such size that the whole of the contents can be discharged in one operation into the vehicle which is being used for distributing the concrete. Suitable sizes of mixers are as follows :—

For distribution in concrete barrows—3½ cubic feet output capacity.

For distribution in concrete carts—5 cubic feet output capacity.

For distribution in narrow gauge rail skips—8 cubic feet output capacity.

For distribution through a hopper—½ cubic yard output capacity.

For a normal type of building a ½ yard mixer is the largest that will be required. A mixer, the output of which is larger than circumstances require, will usually result in over-mixing the concrete.

The use of gauge boxes for measuring the sand and the ballast is unnecessary, as it considerably slows up the process of loading the mixer. The sand and the aggregate can be accurately measured in the barrows or carts which are being used for loading the material into the mixer or loading hopper. Unless the mix is of such a size as to require a whole bag of cement the cement should be measured in an accurately proportioned gauge box.

The use of a loading hopper to the mixer will depend upon the lay-out of the plant. Where conditions are suitable the loading hopper will be found to economise labour. Materials should be placed into the mixer dry. After two turns of the drum the water should be added slowly and in measured quantities. If the mixer is provided with a water tank it should be of such design that the quantity discharged can be easily adjusted. A locking device on this adjustment will prevent the unauthorised alteration of the water content. In a well-designed mixer the concrete should be thoroughly mixed in 60 turns or not more than three minutes.

Mixing in Hot Weather. In very hot weather, when the materials are exposed to the full heat of the sun, the temperature of the mix may be so raised as to cause a flash set in the cement. If there is any sign of this the materials should be protected from the sun or kept sprinkled with cold water.

Mixing in Cold Weather. It is seldom economical in this country to take the necessary steps to enable mixing to be carried out in freezing weather. If the length of the frost or the urgency of the work should demand this, then concreting can be safely carried out if the necessary precautions are taken. The temperature of the materials used in the concrete should be raised to about 90°F. by stacking the materials over hot water pipes fed by a small boiler. The mixing water should also be heated to about 90°F., in which case any automatic measuring device on the mixer should be dispensed with and the water obtained from a tank which is kept up to the required temperature by the addition of hot water from the boiler. The concrete should be conveyed as quickly as possible to the work. If chutes are used these must be protected by covering them over with sacking. If the cold is so intense that the concrete freezes during conveyance through the chutes, the chutes should be dispensed with and replaced by barrow runs.

The concrete, when placed in position, should be kept from freezing by putting coke braziers beneath and a line of braziers on the windward side of the work. The temperature of the concrete must be kept above freezing point until the final set has taken place, and the surplus water dried off, i.e., for about two days. No harm would come to concrete if frozen before the final set, providing it is allowed to thaw out slowly. The most critical period for freezing is between the final set and the initial drying-out. No harm will come to concrete which has frozen after it is dry, providing it is not subjected to vibration and it is carefully protected from the sun so as to ensure slow thawing. All concrete which has frozen should be "suspect" and the centering should not be struck until a thorough investigation has been made, and the foreman would be well advised to take a second opinion before coming to a conclusion.

CONCRETE PLACING.

Before concrete is placed in any particular portion of the work, a careful inspection must be made to ensure that the reinforcement is properly placed and the centering is adequately and properly braced. The forms must be carefully cleaned of all sawdust, wood, dirt, or other foreign matter, particular attention being given to the bottom of the column boxes, in which a moveable shutter should be provided for this purpose. In examining the props beneath the centering, special attention should be paid to folding wedges and the lock nuts if patent props are used. Failure to pay attention to these items has caused many accidents with loss of life. In dry weather the timber of the centering should be thoroughly soaked in water to prevent the absorption of the cement into the pores of the wood, which will result in the timber pulling away the face of the concrete during the process of striking. The soaking of the timber can usually be avoided if a proper form cream is applied as soon as it is erected. Timber centering should as far as possible be protected from the sun so as to minimise twisting and warping.

The concrete must be placed in position as soon as possible after leaving the mixer. Any mixed concrete remaining over at the end of the day must be thrown away. In no circumstances should it be used in reinforced concrete.

Concrete should not be tipped directly from the barrow or chute into the forms except in columns or large members. For small members it should first be tipped on to a board alongside the work and placed into forms with shovels. If an attempt is made to tip the concrete straight into the forms the boxes and reinforcements become obscured from view, and it is impossible to ensure that the member has been properly filled.

The bottom portion of beams comprising the main tensile reinforcement should be filled in in small quantities until it is certain that the steel is thoroughly surrounded. A gentle movement of the reinforcing steel will assist in this consolidation. Prodding concrete with sticks is of little value, for if the concrete is of proper consistency the withdrawal of the stick will tend to leave a void. Vibration applied with a shovel or large rammer gives better results.

Before commencing to pour concrete into a column box, at least 1in. of rich cement grout should be poured into the bottom of the mould. The concrete can then be poured continuously, the only limit to the height at which it can be poured in one operation being the strength of the binding to the formwork. During pouring, the concrete should be continually agitated by a long rammer with a large head. Hammering on the outside of the column box will help the concrete to flow, and result in a good face on the finished work.

Particular care must be taken to see that all reinforcement has the specified cover, especially in members exposed to the outer atmosphere. The best way to do this is to place concrete spacing pieces to each bar and wire them firmly to the reinforcing steel to ensure that they are not displaced during the process of placing the concrete. A special design of spacing block has been prepared by the Trussed Concrete Steel Company, from whom the necessary particulars can be obtained.

When concrete is wheeled from the mixer to the work over the centering, properly designed runways should be provided in order to spread the load. Money spent on such runways is adequately repaid by the saving in wheeling costs. Concrete should not be wheeled in such a way as to vibrate the work which has been recently cast. If the concrete is conveyed by means of a tower and chutes, special attention should be paid to the design and the slope of these chutes. The advice of the makers should be obtained on these points. With correctly designed chutes no rolling should take place. This can be tested by observing the movements of coloured objects placed in the top of the chute at measured intervals. If the concrete is being conveyed by sliding only these objects should reach the bottom of the chute on top of the concrete and at the same intervals at which they were originally placed. The best inclination for a chute is the minimum at which the concrete will flow steadily.

STOPS IN CONCRETE.

Concreting can seldom be carried on continuously. The day's work should therefore be so designed that stops are made where of least harm to the work. The general principle underlying the stopping of concreting is to make these stops along the line of maximum compression and minimum shear. All beams should be stopped within their middle third. Floor slabs should not be stopped over a beam. The stops should be made parallel to their supporting beams and not nearer than four feet to the beam. On no account should a beam be stopped at its support on any other beam, column or wall. All stops should be at right angles to the main reinforcement, i.e., vertically in beams and horizontally in columns. The centering to form the stops should be firmly fixed and scribed round the reinforcing steel. If any concrete flows past this stop it should be hacked off as soon as the concrete has congealed. Before new concrete is placed up against the stop the face of the concrete previously placed should be hacked or preferably scoured with a wire brush so as to remove scum. The joint should then be thoroughly soaked with water and covered with a creamy cement grout. Care should be taken in casting the second half of a stopped beam not to lift the reinforcing steel, as this will tend to crack the concrete previously placed.

In casting beams of tee section it is not always practicable to cast the slab at the same time as the rib. When cast at different times, the interval should be as small as possible, and the top of the concrete in the rib should be roughed and freed from laitance. The construction joint should in no case be lower than the bottom of the slab.

Stops are avoided by continuous concreting, but this is not recommended except in special cases, such as cylinders, water tanks, etc., as night work is very difficult to supervise and the quality of the work must suffer through lack of proper lighting. A well-made stop is preferable to the uncertainty of night work. If the particular circumstances of the work require stops to be made other than in the places indicated above, special permission should be obtained from the engineer in charge of the work. Advice on such matters can always be obtained from the Trussed Concrete Steel Company.

RECORDS.

The clerk of the works and the foreman should mark prominently on the plans the date when each part of the work is concreted. This recording should be done at the end of each day's work.

TESTS ON CONCRETE.

Three tests should be taken from the actual concrete as delivered into the work at least once a week or for each important part of the structure. These test pieces should be cast in steel moulds, either 6in. cubes with die-square sides or cylinders 8in. long 4in. diameter. In order to obtain results comparable with the concrete in the actual members, more tamping must be done in a small cube than in the member itself, owing to the action of friction on the sides. The concrete should be filled into the mould in layers not exceeding 2in., each being thoroughly tamped with a 3in. square rammer, giving 36 blows to each layer. At the conclusion of the filling the mould should be gently tapped with a hammer.

As soon as the mould is filled it should be covered up with a wet sack and not moved for 24 hours, or until the concrete has thoroughly set. After two days the test piece should be removed from the mould and stored in damp sand or sawdust away from draughts or the rays of the sun. A test piece otherwise treated is of no value, as the results of the test will not be comparative. The test pieces should be crushed at seven days, 28 days, and three months respectively. After the first test it will usually be sufficient to crush all further test pieces at 28 days.

CURING CONDITIONS.

The after-treatment of concrete has a very important bearing on its properties. Cement cannot set except in the presence of water at a temperature well above the freezing point. Concrete must therefore never be allowed to dry out until it has reached the required strength, or until it has become sufficiently impermeable to retain water in its mass. The porosity of a concrete will govern the time that it must be kept wet. The minimum time must be seven days, but with a porous concrete this should be increased to fourteen days. The strength of a concrete cured in water will, at 28 days, be 12 per cent. greater than that of one cured in the air.

CONCRETING WITH ALUMINOUS CEMENT.

All the above notes also apply to concrete mixed with aluminous cement, but particular attention should be paid to the following points. Aluminous cement hardens very rapidly after the final set has taken place, giving off a considerable amount of heat, therefore more water should be used in the mixing than with Portland cement. To make up for the loss of water by evaporation all forms should be very thoroughly wetted and the cast concrete kept continuously soaked from the time it commences to harden and for 24 hours after.

To obtain the best results from aluminous cement the sand and the aggregate must be quite clean and free from lime or chalk.

Aluminous cement concrete must never be cast against "green" Portland cement concrete or *vice versa*, as the junction of the two causes a flash set. A good bond can be be made providing one of the concretes has thoroughly set, but the joint must be freed from laitance or scum and well soaked in water.

CONSTRUCTION OF CENTERING.

All centering must be so constructed as to withstand the weight of the reinforcing steel, the wet concrete, and the men placing it without deformation. It is better to err on the side of strength, as rectification is always a difficult and expensive matter.

Sheeting not less than 1¼in. in thickness will be found to pay, as it is less inclined to warp and results in considerably less damage during striking.

The falsework for a reinforced concrete building should always be designed with a view to its easy striking in preference to easy erection. If adjustable props are not used thin folding wedges must be provided to each. The purpose of these wedges is not only to allow for adjustment during erection, but to enable the striking to be done without jarring the concrete.

When constructing beam centering the sides should be made first and framed up into panels which should be at least 2in. deeper than the beam below the slab. The beam bottom should then be cut to the exact width of the beam and fixed between these side panels. The beam bottom should be cut in three pieces, the centre one being about 1ft. long. This will enable the necessary camber to be placed in the soffite of the beam, and if the beam is propped beneath the short piece in the centre, then the beam sides and the remainder of the beam bottom can be struck, leaving the beam supported. On the upper floors the columns usually reduce in size, thereby increasing the length of the beam centering. In this event the extra length can be made up by increasing the size of the small pad in the middle of the beam bottom.

Column boxes should be made on a similar principle to that of the beam boxes. Two of the sides, preferably those parallel to the beam resting on the column, should be made 5in. wider than the actual size of the column, the remaining sides being to the exact size and placed inside the first two. Very few nails should be used in putting these boxes together, but the columns should be strongly braced by means of clamps, either one of the patent clamps now on the market, or strong frames made up of two deals held together by long bolts. The deals should be placed against the long sides of the column box, the shorter sides being fixed by wedging against the bolt.

When erecting the shutters for the concrete walls, concrete spacing pieces with a hole through the centre, the length being the exact width of the wall, should be used as distance pieces between the two shutters. The bolts or wires used for fixing the shutters together could then be placed through the hole in this distance piece and the shutters bolted or windlassed up until they are quite tight.

Removal of Centering.

The greatest care is necessary during the removal of centering. The strength of the concrete should be thoroughly tested before instructions are given to remove any falsework. A workman removing any props, without the direct authority of the foreman, must be severely dealt with. Striking should always be commenced by the loosening of all the wedges in the area to be dismantled. Undue force should never be used, as a considerable weight can be applied to the structure during the process of ramming out a tight prop, and as such a force is usually applied in the opposite direction to that for which the member was designed, damage can easily be done.

A leading hand and a gang of three or four men should be carefully trained in striking work, as experience in this department of construction will not only obviate damage but will considerably save labour costs and damage to timber.

Beam sides should always be struck first, then the soffite of slabs and lastly the soffite of beams. This procedure should be carefully borne in mind when the centering is being erected.

Owing to the many varying conditions it is very difficult to lay down definite rules as regards striking times, but the following are principles underlying all decisions in this matter :—

A member designed for a light superimposed load should be left up longer than one designed for a heavy superimposed load, as at the time of striking the former will receive a much larger proportion of its total load than the latter.

The concrete in a short span member is seldom designed to be stressed up to the maximum working stress in the concrete, and can, therefore, be struck earlier than a long span member.

If the concrete has been carried out in accordance with the specification, it will have attained a strength of four times the working stress after twenty-eight days if matured during normal setting weather, i.e., in a fairly damp atmosphere with a day temperature above 50°. Setting is retarded by extremely dry weather or by cold. The whole time during which the temperature is below 35° should be deducted from the setting time. If the concrete has, during this period, been frozen, or if the cold spell has lasted for several days, three days should be added to the setting time after the frost has given out to enable the inside of the concrete to return to a setting temperature.

A rough and ready rule is to allow half a day per foot of span, with a minimum of two days for slabs and four days for beams. These times should be doubled if the design has been made for a light superimposed load. If modern rapid-hardening cements are used the half-day per foot of span can be allowed for any loads.

For concrete mixed with aluminous cement, supports can be removed after 40 hours from the time of casting for any type of member. The sides of beams, soffites of short span slabs, etc., should be removed where possible after 12 to 16 hours, so as to facilitate wetting the concrete, which is so important during the first 24 hours.

The only safe guide is the result of a test cube taken at the time of casting. Striking can take place when a result of 3000lbs. per square inch for 1 :2 :4 concrete and 4000lbs. per square inch for 1 :1 :2 concrete has been reached. If no test cubes have been taken then the concrete should be inspected and tested by means of a hammer. If, after a moderate blow with a carpenter's hammer, the concrete rings hard and the head of the hammer rebounds, then the concrete will usually have attained the required strength. If the sound is wooden and there is no rebound, striking should certainly be delayed.

REINFORCING STEEL.

As the reinforcing steel is received it should be carefully checked with the advice notes, any missing bars being immediately recorded to the railway company or carters. The advice notes should then be checked with the bending schedules, so that each bar is identified, and stacked according to the part of the work in which it is to be used. The bars are usually despatched in bundles marked in accordance with the letters and numbers shown on the drawings. These markings are either on metal tabs or painted on the bars. It is important that these markings should be preserved in such a way that if a portion of the bundle is used the remaining bars can be identified.

Steel Bending. For most jobs it will be found more economical for the bending to be done at the steel supplier's yard. The advantage of receiving steel ready bent is that it is more easily identified with the bending schedules. When bending is carried out on the site it is important to insist that all bends should be made cold. The operation of bending should be carried out gradually and evenly and not by means of sudden jerks. A jerky action is liable to break or crack even the best steel. Bending should be carried out on a large, strong table with plenty of room all round to manipulate the bars. If a large amount of bending is to be done it will be found economical to have a table, 15 to 20ft. long, with a bar bender at each end, as this avoids turning the bar. Bends should be made strictly in accordance with the schedule. Sharp or sudden sets in a bar must be avoided. Special attention should be paid to the bending of stirrups. Slackness in this operation will cause endless trouble during the fitting of the reinforcing steel in the members. Stirrups to the exact size means accurate and cheap placing. As it is important that every bar has an adequate cover of concrete the stirrups must not be too big, otherwise they will have to be bulged to get the bars into the beam box, thereby minimising their efficiency. Reinforcing steel made under British Standard Specification Grade A will not normally stand straightening out and rebending. Under the initial bend the fibre stress in the steel is high and rebending is very liable to cause a fracture. Rebending, where absolutely necessary, must be carried out with great care and each bend carefully inspected before use.

Steel Placing. As far as possible the bars for one member should be framed up before they are inserted in the beam box. The correct number of bars in accordance with the steel schedule for the work in hand should be collected and checked before steel placing is commenced for the day, otherwise the whole organisation may be thrown out of gear by the absence of one or two bars. It also ensures that no bars are left out of the work. Before any bars are placed, especially in continuous beams, a careful study should be made of the steel drawings and schedules so as to observe which bar passes over another or is continued into the next bay. This will determine the order in which the bars must be placed and will avoid considerable alterations and rehandling of the reinforcement. Generally the main beam steel should be placed first, then the secondary beams, and lastly the slab. All main bars should be carefully and firmly wired to the stirrups. This will prevent the movement of the reinforcing steel during the punning of the concrete. The necessity for the accurate placing of the reinforcing steel cannot be too strongly emphasised. Steel wrongly placed is often as bad as steel omitted. The concrete spacing blocks already referred to should be placed in the corners of all boxes and wired to the reinforcing steel at the time of placing. Many an excellent building has been spoiled by the omission of this simple precaution. No case of trouble has yet been recorded where the reinforcing steel has a cover exceeding 1 in. A spacing block of the design shown will not only space the bars from the face of the beam, but also from the soffite. Special care is necessary in placing cranked slab bars, as these have a tendency to fall over, in which position their utility is largely negatived. This can be prevented by wiring a spare bar across the top of the cranked ends during the process of concreting.

The Decorative Treatment of Reinforced Concrete.

It is only during the last few years that any attempt has been made to improve the appearance of the external surface of a reinforced concrete building other than by means of covering it up with plaster, brickwork, terra cotta, etc. A few recent buildings have shown that concrete, if properly treated, is a material of considerable beauty. The ugliness of concrete is mainly due to the cement scum, and it is on the removal of this that recent efforts have been concentrated.

The main point to be borne in mind is that concrete can be made as pleasing as any other building material, but it requires care and attention to detail in the selection of the aggregate, the placing of the concrete, and the treatment of its surface. The result will warrant any amount of labour being expended on it. Assistance in this problem has been given by the introduction on to the market of such preparations as "Redalon" and "Retardo," which will facilitate the removal of the cement scum. Sufficient work has not yet been done to warrant detailed instructions on the execution of concrete surfaces, but the latest information on this subject can always be obtained by applying to the Trussed Concrete Steel Company.

The Finish of Reinforced Concrete.

In the construction of reinforced concrete, sufficient care should always be taken with the alignment of the centering and the cleaning of the timber to ensure reasonably true lines. Good reinforced concrete work should not be plastered; in fact, cement plastering on concrete should always be avoided as it is very difficult to obtain a proper key or to prevent the applied coat from cracking. Having taken all reasonable care with the centering, the usual method of finishing a reinforced concrete surface is to work upon it immediately the centering is struck by dressing off all projections and roughnesses by means of a Carborundum stone;

then, to rub down the surface with a slurry of cement and sand applied and rubbed-in by means of a thick canvas pad. For better-class work, particularly externally, this surface can be further treated by rubbing over with a piece of York stone before the cement of the previous coat has set. This method applies to nearly every type of finish, the quality of the result depending upon the amount of labour expended upon it.

If the desired finish requires the sharp arrises and straight lines which can only be obtained by plastering, then it is necessary to take special precautions to obtain an adequate key, if satisfactory results are to be achieved. This can be done by thoroughly hacking the surface immediately the centering is struck, or preferably by the use of a retarding medium painted on the centering, brushing out the external skin by means of a wire brush immediately the centering has been removed. The latter will usually prove to be a cheaper and more efficient method.

Cutting or Forming Holes in Concrete.

The foreman should never allow any holes or chases whatever to be cut in a reinforced concrete framework without his express knowledge and permission. It is always very much cheaper and safer to cast the necessary holes in the concrete members rather than to cut them after the concrete has set. When casting small holes for the passage of pipes, etc., slightly tapered circular plugs should be securely fastened in the correct position to the shuttering. A supply of these should be kept constantly soaking in water, so that they can be placed in the work when fully swollen.

For holes which are too big to cast with a solid plug, a frame-box should be used, which should be of as light a material as possible to assist in the removal. No hole which will cause the omission or displacement of any reinforcing bar should be cast in a member until the matter has previously been sanctioned by the architect and revised reinforcing details have been obtained. If a hole exceeds $1\frac{1}{2}$in. in diameter, then the plug should be surrounded by a spiral wire coil; this coil should be about 1in. pitch and $1\frac{1}{2}$ times the diameter of the hole. When a hole comes in a member subject to heavy shear or compression a steel sleeve may be necessary.

Alterations to Existing Reinforced Concrete Work.

Reinforced concrete is one of the easiest building materials in which to make alterations, but these should always be properly considered and designed. The Trussed Concrete Steel Company are always in a position to prepare alteration schemes for any building erected according to their designs.

In carrying out an alteration involving cutting-out, the surrounding members should be thoroughly propped without undue force. The cutting of the concrete should be carried back beyond the limits of the hole required until sufficient stirrups or bars have been exposed to which an efficient connection can be made. In re-casting new concrete on to old, the greatest care should be taken to cleanse thoroughly the old surface from dust, and to remove all loose or shattered portions. A wash of cement grout should be applied immediately prior to the placing of the concrete.

If a considerable portion of a large concrete beam or column is to be removed, it is wise to expose the steel at the position where it will be cut and to cut it through before the remainder of the concrete is broken up. This will prevent the impact, caused by cutting the concrete, from loosening the reinforcing steel in that portion of the beam which is to be retained.

Fixings to Concrete Structures.

Where provision is to be made for the subsequent fixing of machinery, fittings, or finishings, the nature of these should be ascertained before any concrete is poured.

For light fixings which can be carried out by means of a wood screw, a dovetailed teak block or fillet is quite satisfactory. Care should be taken to use only a true teak. Deals, or hardwoods other than teak, are not generally suitable. These fillets or blocks should be anchored by skew-driving a sufficient number of wire nails into the back.

For fixings by means of bolts, special fittings, such as Bolt Hanger Sockets, Slotted Inserts, or other well-designed fixing should be used, care being taken that these are accurately placed and firmly held so as not to be displaced during the process of tamping the concrete. For isolated fixings, the positions of which cannot be ascertained before the work is cast, holes should be jumped or drilled and fitted with one of the numerous expanding metal or fibre blocks, such as Rawlplugs for small fittings by means of a screw, or "Keystone" for larger fittings where a bolt is required.

A Few Hints Useful in the Execution of Special Structures.

In the construction of a retaining wall the method to be adopted in carrying out the reinforced concrete work must be fully considered before the shoring to the excavation is put in hand, to ensure that re-shoring is eliminated and that the wall can be executed in the lengths between two shores, and that the shores do not interfere with any main members of the design, such as columns, beams, or counterforts.

Where a retaining wall is to withstand water pressure, it is important to make an efficient joint between each section. This can best be done by forming a splayed joggle joint and thoroughly roughing the concrete face. If this is in such a position that it cannot be got at for hacking, the use of a retarder painted on the stopping board will be found very efficient. Before casting the next section, all dust or loose particles should be removed from the old concrete, which should be thoroughly soaked and grouted with cement. Particular care should be taken with the ramming of the new concrete at this section.

For all waterproofed structures, particular care must be taken in the selection and grading of the aggregates. This point has been fully dealt with in the earlier sections of this hand-book.

When concreting a water tank or other structure designed to withstand or to contain a liquid, the amount of concreting per day should be so designed that a complete ring of the structure can be cast in order to avoid vertical joints. The horizontal joint must be thoroughly cleaned before the next day's work. There is a tendency for the scum of the cement to collect at the top, which may set quite hard by the next morning, but will never be watertight. The removal of this scum is best done by scraping the cement after the initial set and washing the scum out with a strong jet of water. An inch of stiff grout poured into the centering immediately before concreting is commenced will assist in obtaining a strong and watertight joint.

Through wire ties or bolts should always be avoided in such structures, as it is almost impossible to block the holes left after their removal. If wires are left in the concrete, the rusting of these will continually stain and disfigure the work. There are many types of special clamps on the market which are quite effective and which obviate the necessity for these continuous holes or wires.

For all large structures it is necessary to consider the question of expansion and contraction joints. Such joints should be provided with a view to taking up any of the movements resulting from the expansion or contraction in the steel and the concrete due to a variation in temperature above or below the average pertaining during the hardening period of the concrete, also any movements due to the natural contraction in the concrete during the ageing and hardening period. This latter will depend upon the nature of the concrete and the conditions of curing, and has little relation to the strength of the concrete. When such joints have been incorporated in accordance with the instructions of the architect or the engineer, care must be taken that corresponding joints are made in any finishing material applied directly to the structure. Contraction cracks in concrete floors will usually coincide with the stopping joints between the various day's work. The corresponding joints should therefore be left in the granolithic, terrazzo, or other mastic floor covering. It is seldom worth while to allow a contraction joint in plastering, as this is more easily repaired.

Loading Structures.

The load for which any structure is designed should always be ascertained by the foreman and kept constantly in mind. Care must be taken that the full working load is not applied until after the expiration of two months from the date of casting, unless special investigation has been made.

Where structural loads must be applied to concrete before it has thoroughly aged, these should be concentrated as far as possible, firstly, around the columns, and secondly, over main beams. The centre of floor panels should not be loaded.

If a test load is called for on any portion of the structure, the necessary deflectometers, together with a design giving the best position for these, can always be obtained from the Trussed Concrete Steel Company. In applying a test load, great care should be taken that sufficient space is left between each unit to prevent binding or arching.

A Final Word.

The clerk of the works and the foreman have extremely important and responsible duties to perform. Any lack of care on their part may endanger the entire structure, and possibly cause loss of human life. Failure on their part or on the part of their workmen to follow and carry out the instructions received by them, either on drawings, in letters, or in specifications, may even result in a criminal charge of negligence. This point is stressed merely to indicate the importance of thoroughly understanding the instructions which have been given, and of taking no action on the reversal of written instructions by verbal instructions.

The foreman should take absolutely no orders from any person other than those expressly authorised to give them. In this connection it should be remembered that the owner, having appointed an architect to act on his behalf, is not authorised to give instructions directly to the foreman or through any other person than his architect. The foreman should respectfully but firmly indicate to any such person that no orders can be taken unless they are confirmed in writing by the architect.

USEFUL INFORMATION.

Round Bars. Areas and Weight.

Diameter.	Weight in Lbs., per Foot run.		Area, In Sq. Inches.
	Actual.	Approx.	
$\frac{1}{4}$ in.	·167	$\frac{1}{6}$	·049
$\frac{3}{8}$ in.	·376	$\frac{3}{8}$	·110
$\frac{1}{2}$ in.	·668	$\frac{2}{3}$	·196
$\frac{5}{8}$ in.	1·044	1	·306
$\frac{3}{4}$ in.	1·503	$1\frac{1}{2}$	·441
$\frac{7}{8}$ in.	2·046	2	·601
1 in.	2·673	$2\frac{2}{3}$	·785
$1\frac{1}{8}$ in.	3·382	$3\frac{3}{8}$	·994
$1\frac{1}{4}$ in.	4·176	$4\frac{1}{6}$	1.227
$1\frac{3}{8}$ in.	5·058	5	1·485

Approximate weight of materials in lbs. per cube foot.

Materials	Lbs., per Cu. Foot
Concrete Brick Aggregate	115 to 125
,, Shingle ,, ...	140 to 150
,, Granite ,, ...	150 to 160
Reinforced Concrete (add to above) ...	5 to 10
Steel	490
Portland Cement	85
,, Stone	135
Granite Blocks	165
Brickwork (Stocks)	105 to 120
,, (Blue)	135
Coal	50 to 56
Coke	28
Vegetable Earth	100 to 110
Timber (Red Pine)	40
,, (English Oak)	53
,, (Teak)	47
,, (Mahogany)	35
Water	62.4
Snow (fresh)	7
,, (moistened)	30

Materials required per cubic yard of Concrete

(Allowance has been made for waste).

Mix	Cement, Ft. cube	Sand, Ft. cube	Shingle or *Ballast, Ft. cube
1 : 1 : 2	10¼	10¼	20½
1 : 1½ : 3	7½	11¼	22½
1 : 2 : 4	6	12	24
1 : 3 : 6	4¼	12½	25
1 : 4 : 8	3¼	12¾	25½
1 : — : 2	11½	—	*23
1 : — : 4	6¾	—	*27
1 : — : 6	4¾	—	*28½
1 : — : 8	3¾	—	*30
1 : — : 10	3⅛	—	*31¼

Approximate Weight and Volume of Concrete Aggregates.

Material	Weight, Cwt. per Cube Yard	Volume, Cube Feet per Ton
Sand	22	24½
Shingle (¾in. to ¼in.) ...	22	24½
Ballast (as dredged) ...	25	22
Whinstone	21	26
Broken Granite (Leicester) ...	20½	26
Broken Brick	19½	28
Coke Breeze	9½	56
Pumice (Italian)	6⅔	80

Sand, shingle and ballast are measured Semi-dry, the condition in which they are generally delivered to contracts.

Timber Measurement.

Lineal feet per standard of 165 Cu. Ft.	
3in. by 1in.	7,920 ft.
4in. by 3in.	1,980 ft.
7in. by 2in.	1,697 ft.
9in. by 2in.	1,320 ft.

Lineal feet per square	
Width 4in.	300 ft. run
„ 5in.	240 „ „
„ 6in.	200 „ „
„ 7in.	$171\frac{2}{5}$ „ „
„ 8in.	150 „ „
„ 9in.	$133\frac{1}{3}$ „ „
„ 10in.	120 „ „

Weight	
Unsawn Deals	2 tons 10 cwts. per standard
Sawn „	2 tons 2 cwts. per standard

NOTE.—The price per square of 1in. boarding if multiplied by 20 is *approx.* equivalent to the price per standard, thus 22/- per square 1in. thick is about £22 per standard.

Number of Wire Nails per lb.

Length of Nail	No. per lb.	Length of Nail	No. per lb.
1 inch wire	600	3 inch wire	60
$1\frac{1}{2}$ „	280	4 „	44
2 „	120	5 „	28
$2\frac{1}{2}$ „	96	6 „	17

Weight per foot super of various building materials as generally stacked on floors including voids or spaces.

Material	Weight per foot super per foot of height.
Ballast and sand	60 lbs.
Cement in sacks	70 lbs.
Lime in sacks	40 lbs.
Plaster in sacks	80 lbs.
Mortar in heaps	84 lbs.
Bricks stacked	81 lbs.
Stone in block	98 lbs.
Stone in slabs on edge	128 lbs.
Steel rods	290 lbs.
Steel sections	190 lbs.
Nails, bolts and rivets in bags	200 lbs.
Lead in rolls	350 lbs.
Lead pipe in coils	280 lbs.

The weights given are approximate for the average method of stacking and per foot of average height.

Thickness and Weight of Steel Sheets.

No. of Gauge	Thickness in inches		Weight in lbs. per sq. ft.	
	B.G.	S.W.G.	B.G.	S.W.G.
30	.0123	·0124	·502	·506
28	·016	·015	·637	·604
26	·020	·018	·800	·734
24	·025	·022	1·01	·898
22	·031	·028	1·27	1·14
20	·039	·036	1·60	1·47
18	·049	·048	2·02	1·96
16	·062	·064	2·55	2·61
14	·078	·080	3·20	3·26
12	·099	·104	4·04	4·24
10	·125	·128	5·10	5·22
8	·157	·160	6·41	6·53
6	·193	·192	8·03	7·83
4	·250	·232	10·20	9·47
2	·315	·276	12·84	11·26
1	·353	·300	14·41	12·24

Note.—The old B.W.G. is now obsolete and is not shown. The B.G. is generally used for steel and iron black or galvanized sheets. The S.W G. is more frequently used for wire and tubes.

Weight and thickness of Sheet Zinc.

B.W.G.	Thickness in inches	Zinc Gauge	Weight in ozs. per sq. foot
27	.017	9	10¼
25	·019	10	11½
24	·022	11	13¼
23	·025	12	15
22	·028	13	17
21	·031	14	18¾
20	·035	15	21¾
19	·041	16	24¾

Thicknesses of Sheet Glass and Lead.

Sheet Glass		Sheet Lead	
16 oz. ...	0 077 ins. thickness	4 lbs. ...	0·068 ins. thickness
21 oz. ...	0·101 ins. ,,	5 lbs. ...	0·085 ins. ,,
26 oz. ...	0·125 ins. ,,	6 lbs. ...	0·102 ins. ,,
32 oz. ...	0·154 ins. ,,	7 lbs. ...	0·119 ins. ,,
		8 lbs. ...	0·136 ins. ,,

Decimal Equivalents of a Foot.

Inches	0	¼ Inch	½ Inch	¾ Inch
0	·0000	·0208	·0417	·0625
1	·0833	·1042	·1250	·1458
2	·1667	·1875	·2083	·2292
3	·2500	·2708	·2917	·3125
4	·3333	·3542	·3750	·3958
5	·4167	·4375	·4583	·4792
6	·5000	·5202	·5417	·5625
7	·5833	·6042	·6250	·6458
8	·6667	·6875	·7083	·7292
9	·7500	·7708	·7917	·8125
10	·8333	·8542	·8750	·8958
11	·9167	·9375	·9583	·9792

Lineal Measure.

66 feet make 1 chain.
22 yards make 1 chain.
4 poles make 1 chain.
1,760 yards make 1 mile.
80 chains make 1 mile.
8 furlongs make 1 mile.

Square Measure.

9 square feet make 1 square yard.
4,840 square yards make 1 acre.
160 perches make 1 acre.
4 roods make 1 acre.
640 acres make 1 square mile.

MEMORANDUM.

MEMORANDUM.

MEMORANDUM.

MEMORANDUM.

MEMORANDUM.

funding provided by:

the Vera Moore Foundation, Australia

vera moore